A Cost Effective Algorithm for Grading Raisins Using Image Processing

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Abstract— Grading of agricultural products is done to get the good quality of products, which also means to separate or remove poor quality of products, to increase the quality of productivity. Grading of the products is either done manually or using some machineries. Recently few automated systems are developed using image processing technology for grade the agricultural products. The products which can be graded automatically include fruits, grains, dry fruits etc. There is a need to develop an automated system using image processing to make grading easier. This paper presents an algorithm for grading raisins using image processing. The system first reads an image from the file and then the image is passed for processing. The image is captured using high resolution mobile camera of 16 megapixels. Processing includes many steps like image pre-processing, feature extraction, classification and grading. The system is developed using Matlab. Classification and grading is done on the basis of color and size. The classifier used is neural network and the grades used are industrial grades. The results are precise and accurate with average recognition rate of 95%.

Keywords— Raisins, Automatic Grading, Feature Extraction, Neural Network, Industrial Grades

I. INTRODUCTION

Agriculture plays a major role in development of Indian economy. In fast growing countries like India, production of raisins is in large scale. Grading of raisins for the export and internal usage traditionally uses manual procedures or some machinery based on size sieves. These machines used are very costly and are equal to a size of room. These machineries are called sorter machines. Sorter machines are different for different fruits and grains based on their sizes. Farmers feel it better for hand picking of fruits. Manual grading is laborious, tedious, time consuming and inaccurate. The poor classification and sorting will lead to reduction in quality assurance. Due to these drawbacks of manual grading like tediousness, labor requirements, inconsistency and huge price of machines, an automated grading system needs to be developed which is affordable by small traders and farmers. Automatic grading system improves the quality of product, increases production and also reduces the dependency on manpower.

The manual sorting and grading has been replaced by machine vision system which has many advantages like high accuracy, uniformity and processing speed. Grading of agricultural products is done to identify the quality of the product and to separate the good quality from poor. Raisins are graded to get the best quality according to industry standard. Automated system uses different types of algorithms to extract features of the fruits and technologies for classification of the fruits. Automatic grading system is adopted in order to overcome the problems of manual grading.

Recently Mollazade et al. [1] developed a process for grading of raisins based on shape and color features for data mining of these different classifiers used ANNs, SVMs, DTs and BNs. Xinjie et al. [2] used LSSVM for classification of color and texture features for classification of raisins. Xiaoling[3] found the various physical parameters of raisin and for classification Neural network was used. Abbasgholipour et al. [4] used permutation coded genetic algorithm for segmentation of the raisin image and for selecting desired and undesired raisin, HIS color space is used. Omid et al.
[5] has developed Microcontroller based electronic system for grading raisins based on their size and color. The studies have applied algorithms on individual raisins which is computationally costly. However, in reality the judgmental grading of raisins is based on the bulk quality of raisins.

The paper presents an algorithm which can grade the raisins in industrial standards. The system extracts 19 features using which the classifier is trained and testing is done. The images are captured using mobile camera of 16 megapixels. Then this image undergoes various steps like pre-processing and feature extraction. Then the classifier is implemented through which classification of images is done. The work in this paper considers seven industrial grades of raisins. The remaining part of the paper is organised into four parts: the overview of automatic grading, explanation of proposed system, results and discussions and finally conclusion. The four parts are introduced as follows

II. AUTOMATIC GRADING: OVERVIEW

Application of image processing in the field of agriculture has made tremendous improvement in production and quality of the product. It is also used to identify the disease in the early stages. Computer vision and image processing are used as non-destructive, reliable and accurate methods to reach the standard of grading. Grading is even used for vegetables like roots, tomatoes, mushrooms. The techniques used in image processing are like image segmentation, noise and background elimination, shape and morphology analysis, texture and size analysis, pattern recognition and many more. Using image processing fruits quality is detected by using vision detection technology.

There are many choices for grading fruits. Few of those which are used frequently are color, size and texture. Many color vision systems are been developed for grading agricultural products. Few of them are direct color mapping of quality of tomatoes, automates inspection of golden apples using computer vision. Some machine vision systems are designed for factory automation task. For grading the automatic system may extract color features using RGB or HSI model and then classification and sorting according to grades is done using classifiers like fuzzy logic, support vector machines, neural networks or KNN.

The general working of automated grading system is described here. In the first step the image can be captured using regular digital camera or a high resolution mobile camera. This image is given to the system for grading. Grading here involves steps like feature extraction, shape and size based sorting and grading is done. Here image processing is used to extract the features of the image like color features, texture features and geometric features. Based on features extracted the fruit is classified to its class using classifier technologies. The system is implemented d using Matlab software.

A. Raisin Types and Grades

India produces raisins in bulk. There are many grades and types in raisins. They differ with color shape and size. The types given below are the industry standard grades. The following are varieties of raisins available and their characteristics.

I. Green Raisin

Characteristics:

- Usually green in colour.
- Long and round shaped berries.
- These are prepared through dipping in oil and dried in shades to get the peculiar colour and taste.
- These are similar to Chinese and Afghan variety.
- Mainly used as a table premium variety.
2. **Golden raisin**

Characteristics:
- Usually golden in colour and some are bright sunshine gold in colour.
- Long and round shaped berries.
- These are prepared by dipping in oil and dried in shade to get the colour and taste. Some are prepared by treating in sulphur and dried in racks.
- These are used as table variety, food additive and high value food industry.
- These are similar to Iranian golden raisins.

Grades:
- Grade 1
- Grade 2

3. **Brown raisins**

Characteristics:
- These are brown and dark brown in colour.
- These are prepared through dipping in oil and drying in shade some are directly dried in sunlight.
- These are used in bakery, confectionery, ice-cream, medicinal and other culinary products.
- These are similar to American Thomson seedless raisins.

Grades:
- Grade 1
- Grade 2

4. **Black raisins**

Characteristics
- These are black in colour made from black grapes.
- These are long and round in shape.
- These are prepared by dipping in oil and dried in shade to get the colour and taste.

Grades:
- Grade A
- Grade B

III. **PROPOSED SYSTEM**

Grading of agricultural products is very important to identify its quality. Raisins are graded by its size and colour. Existing systems sort either by colour and size. There are some systems in which raisins are sorted by colour and size but those systems are grade raisins of same colour into subcategories and these are not industrial standard grades. As the raisins available in the market will be available in different grades, so the raisins must be sorted and graded according to industry standards. So farmers and small dealers need a system which grades the raisins according to industries standard. So the previously developed systems cannot be used by farmers.

The System architecture is give below. It shows that the system is subdivided into various modules, like pre-processing, feature extraction, segmentation, Classification/grading. Classification is done using feed forward neural network. Raw image is given as the input to system; this undergoes pre-processing of image like background elimination, noise removal. Background removal is done using thresholding. Then the image is segmented to extract individual objects. Segmentation is done using connected components labelling. Then each raisins are extracted into sub images. Feature extraction is done on segmented individual objects. Color feature and geometric features are extracted.
Next classifier is selected and trained. The same classifier is used for grading and sorting of the images. Classification is done on the basis of color and size. The classifier is probabilistic neural network. First the classifier is trained to develop a knowledge base, which helps further in classification. Once the knowledge base is created the images are tested to check if the given output is correct or not and performance of the system is calculated.

Here the system needs to classify the raisins into seven classes. First is the Brown Grade1, second is the Brown Grade2, third is Super Sonaka Gold Grade1, fourth is Super Sonaka Green, fifth is Thomson Seedless Gold Grade1, sixth is Thomson Seedless Gold Grade2, and seventh is Thomson Seedless Green.

Feature extraction is an important part in automatic grading system. The classification relies on the features extracted from the image once he features are extracted. The classifier is trained using these features and are also used for grading of the raisins. The following describes the features extracted and the neural network used.

**A. Feature extraction**

The feature extraction process is done using the Matlab image processing toolbox functions. The extraction process first converts the color image to gray image then to binary image. Then the image is segmented to get single raisin from the image. Segmentation of the image is done using connected-components labeling algorithm. Each segmented image undergoes into feature extraction stage. Image features extracted are area, majoraxislength (length), minoraxislength (width), aspect ratio, RGB moment, RGB variance, RGB standard deviation, RGB mean and HSI mean. Totally 19 features are extracted. The features area, major and minor axis lengths determine the size of the fruit. These features are used for training the classifier and the same features are extracted while testing the image using classifier.

**Table 1: Features extracted**

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Features Extracted</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2,3</td>
<td>RGB mean</td>
</tr>
<tr>
<td>4,5,6</td>
<td>RGB Variance</td>
</tr>
<tr>
<td>7,8,9</td>
<td>RGB Standard Deviation</td>
</tr>
<tr>
<td>10,11,12</td>
<td>RGB moment</td>
</tr>
<tr>
<td>13</td>
<td>Area</td>
</tr>
<tr>
<td>14</td>
<td>Major Axis length</td>
</tr>
<tr>
<td>15</td>
<td>Minor Axis length</td>
</tr>
<tr>
<td>16</td>
<td>Aspect ratio</td>
</tr>
<tr>
<td>17,18,19</td>
<td>HIS Mean</td>
</tr>
</tbody>
</table>

**B. Classifier (Probabilistic neural network)**

The classifier is used to determine the color and the size of the raisin to correctly classify it to one of seven correct classes. The classifier used is the Probabilistic neural network (PNN). To avoid noise a background with controlled light is chosen and the distance between the object and camera are fixed during capturing of images. Figure 3, 4 and 5 shows three types of raisin images.
captured. The data is divided into two sets, training set and validation set. Training set is used for training and validation set is used for testing. The classifier is first trained using the features extracted. After training is done, testing of the neural network for correct classification is done. First the features of the image being tested are extracted and then passed to the neural network. The network gives the output of the class to which it belongs. And the performance is checked by manually testing the system generated output.

![Figure 3. Super Sonaka Gold Grade1](image1)

![Figure 4. Brown Grade1](image2)

![Figure 5. Thomson Seedless Gold Grade2](image3)

### IV. RESULTS AND DISCUSSIONS

The system is designed and implemented using the Matlab. In order to evaluate the accuracy of the system many images are tested in bulk. The below figure (Figure 6) shows the snapshot of the main GUI where the training of the classifier is done by extracting the features of the raisins. The snapshot has the image to be trained, the total number of raisins present in the image, and the values of the extracted features.

The below table (Table 2) shows the accuracy of the system for each class. The results are extremely good. Misclassifications occur if the images contain the raisins in group. The grading results are basically obtained based on the color and the size of the fruit. Color is taken for the classification of the images of different colors. Size factor is considered to sort the images of different size within same color and among different color.
Table 2. Classification accuracy

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Classification/Grading Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown Grade1</td>
<td>95%</td>
</tr>
<tr>
<td>Brown Grade2</td>
<td>97.5%</td>
</tr>
<tr>
<td>Super Sonaka Gold Grade1</td>
<td>97.5%</td>
</tr>
<tr>
<td>Super Sonaka Green</td>
<td>75%</td>
</tr>
<tr>
<td>Thomson Seedless Gold Grade1</td>
<td>85%</td>
</tr>
<tr>
<td>Thomson Seedless Gold Grade2</td>
<td>72.5%</td>
</tr>
<tr>
<td>Thomson Seedless Green</td>
<td>100%</td>
</tr>
</tbody>
</table>

The overall performance of the system is approximated to 95.85%. Figure 7 gives the performance graph of the system.
The ROC graph is also plotted using true positive and true negative values obtained from the system. The ROC graph has the roc curve for all the seven classes. One curve is been overlapped by other i.e., the accuracy of Brown Grade2 and Super Sonaka Gold Grade1 are same.
V. CONCLUSION

The automatic grading system implemented for grading raisins, grades the raisins into industrial standards. The system implemented completely depends on the color features and size features extracted. These features are used for the identification of raisin types.

As the system grades the raisins into industrial standards it can be used by small scale manufactures and sellers. Farmers can also use the system for grading raisins. The system is implemented for the desktop systems. The system can be used to sort other types of agricultural products based on color and size. In future the system can be made as an app for the mobile devices so the users can take it along with them wherever they go.

REFERENCES